

Product-Service Systems across Life Cycle

Requirements for cross-domain Knowledge Sharing in collaborative Product-Service System design

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Abstract

In the case of Product-Service Systems (PSS), the design phase is characterized by a demand for intensive exchange of knowledge between stakeholders from different domains. Thus, a comprehensive approach for knowledge sharing would support the integrated development of PSS. Existing attempts are however mainly focusing on using explicit service knowledge for product design and service operations only. Knowledge exchange between domains, including tacit knowledge and sentiment, for the integrated design of products and services have received less attention. The objective of this paper is to present the initial results on the requirements for cross-domain knowledge sharing when designing innovative PSS.

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1. Introduction

Companies are becoming increasingly aware of the fact that knowledge is a resource requiring explicit management methods, if it is to be processed efficiently: storing knowledge, communicating, forging links and synergy between each individual's knowledge, and generating new collective knowledge [1]. Product and service design is also becoming more and more collaborative. The design of services and physical products requires knowledge that is usually scattered among different persons, departments or even organizations. Manufacturers are working closely with service providers, suppliers and customers to perfect designs of new product-service bundles before they are realized [2]. This network of partners defines the underlying problem and solves it through the application of knowledge, generating new knowledge.

The required knowledge exchange depends on the types of products and services involved and on the depth of their integration. In the case of Product-Service System (PSS),

where the tangible and intangible components are entangled and dependent on each other, the design phase is characterized by a demand for intensive exchange of explicit and tacit knowledge for the engineering process, like user and system requirements, sentiments, competences, design specifications or processing instructions between the involved stakeholders from different domains [3]. To this end, both knowledge from the product side as well as the service side must be shared in an appropriate way, combined and utilized, in order to create an attractive product-service bundle for the customer.

In the scientific discipline of Knowledge Management (KM), several approaches to capture, develop and apply knowledge effectively during product design have been developed. Knowledge-Based Engineering (KBE) for example is aiming at establishing engineering knowledge models, for application in product design and along the whole product life cycle. First attempts have also been made to include service knowledge into a KM framework for PSS as well. These attempts are however focusing on using service knowledge for

product design and service operations only. Furthermore, most approaches have been focusing on explicit formalized knowledge inside an individual organization. [4]

Thus, an integrated approach for knowledge sharing, considering the special characteristics of PSS and avoiding the limitations of the existing approaches is required. It shall enable the stakeholders to exchange explicit and tacit product-service design knowledge beyond organizational borders in order to facilitate an integrated development of PSS. Furthermore, sentiment could be used as an additional source of knowledge. The aim of this paper is to give an outline of the requirements for knowledge sharing in PSS design.

2. Research Approach

The analysis of requirements for knowledge sharing in Product-Service System design is based on a literature review of existing approaches, as well as on the analysis of four industrial use cases aiming to design new PSS. As the work with the use cases is still ongoing, it can be seen as an exploratory approach at this stage.

The literature review has been conducted by accessing scientific papers through the multidisciplinary SCOPUS database, as PSS are a cross-domain research topic. For practical reasons, the search was limited to journal and conference papers in English language. As several expressions are used in literature to describe the PSS concept, we applied *TITLE-ABS-KEY ("product-service" OR PSS OR IPS OR "Extended Product")* as the first search term, combined with *AND TITLE-ABS-KEY ("knowledge management" OR "knowledge sharing")* as the second term.

The search yielded 214 results in total, which were checked for relevance and redundancy by assessing the abstracts. Based on this, 40 papers were selected for in-depth analysis of the content. The literature review was complemented with papers from additional sources, such as Google Scholar. [5]

The outcome of the literature review is discussed in the following sections. In a first step, the role of knowledge in the life cycle of products, services and integrated PSS is analysed. The relevant stakeholders and the knowledge exchanged between them is identified. This is complemented with the results from the use case analysis. Secondly, the State-of-the-Art in knowledge sharing for PSS Design is examined for open issues and gaps. There are several existing approaches, mainly from product engineering, which could provide a good basis for sharing explicit and formalized knowledge. These are assessed towards their suitability for the design of PSS. The main criteria are the suitability for PSS engineering, the underlying processes and stakeholders and the extent to what their re-use or adaption will increase knowledge sharing in PSS design. The analysed approaches then can be selected for further requirements in order to be applicable for PSS.

3. Knowledge in Product-Service System Design

The design phase in the life cycle of products and services is characterized by an intense exchange of knowledge [6]. This even increases if an integrated PSS shall be designed in a collaborative way [7–9]. On the one hand, it has to be

elaborated which process steps are typically conducted in PSS design [7,10,11] (section 3.1). On the other hand, the involved stakeholders have to be identified and described as the relevant knowledge sources and targets [3,7,12] (section 3.2). Based on the results, the relevant types of knowledge and appropriate exchange mechanisms and standards have to be defined [2,7,13] (section 3.3).

3.1. PSS Life Cycle

Based on the targeted integrated design of PSS, product and service life cycle must also be integrated to provide the required interactions during the design phase [7]. Meier and Uhlmann [14] derive a PSS life cycle directly from the combination of product and service life cycle as shown in Fig. 1:

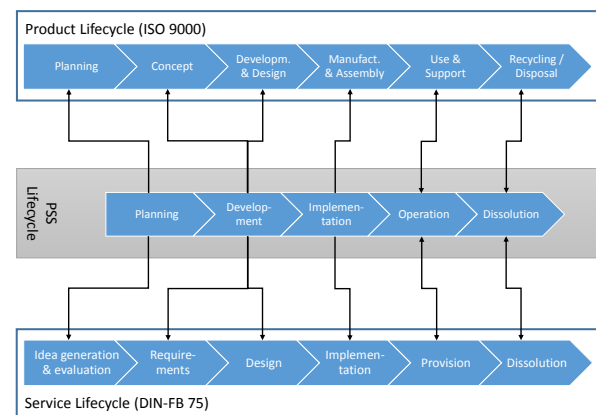


Fig. 1. PSS Lifecycle according to [14].

The PSS life cycle focuses no longer only on the operation, but the satisfaction of customer needs is in the foreground [15], leading to long life cycles and an increased proportion of service [16].

3.2. Stakeholders in PSS Engineering

The PSS Engineering process is characterized by the inclusion of competences in the form of various actors during the development phases [7,17]. These stakeholders are the relevant sources and targets of knowledge and can be assigned to PSS specific roles [3,12,18] for the process.

The Customer initiates the process, because demands towards the PSS will be drawn up and implemented based on the determined customer needs [17]. The PSS Provider or OEM coordinates the design of the product-service bundle [16], while the Production and Service Networks comprises the partners who are responsible for provision of components or services for the PSS Provider [19,20]. The PSS Project Manager coordinates the PSS actors and their knowledge sharing along the development process [21], while the PSS Architect fosters PSS idea generation, documentation and management [22].

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